

**FURTHER CARBON ISOTOPIC MEASUREMENTS OF CARBONATES IN ALH 84001** I. P. Wright<sup>1</sup>, M. M. Grady<sup>1,2</sup>, and C. T. Pillinger<sup>1</sup>, <sup>1</sup>Planetary Sciences Research Institute, Open University, Walton Hall, Milton Keynes MK7 6AA, England (i.p.wright@open.ac.uk), <sup>2</sup>Natural History Museum, Cromwell Road, London SW7 5BD, England (m.grady@nhm.ac.uk).

We have previously suggested that the (somewhat unexpected) results obtained from sequential acid etching of one particular sample of ALH 84001 could be due to the presence of organic materials surrounding individual carbonate grains [1]. Indeed, taking the evidence and conclusions of McKay et al. [2] at face value, and assuming the operation of past life on Mars, we had speculated that the organic materials in question could be due to a biofilm [1], an observation in keeping with features documented by electron microscopy [3]. Whilst the relevance of biofilms in a sample from Mars goes without saying [e.g. 4], it is clearly going to be necessary to constrain the meteoritical phenomena as tightly as possible. As such it seemed appropriate to consider this issue further.

In order to comprehend the results from our original acid dissolution experiments, which involved reclaiming unreacted material at each stage, a further sample of ALH 84001 (subsample 106) was treated, but in this case residual materials were *not* reclaimed after each period of etching. Rather, the meteorite was reacted sequentially with acid but *without* removal of any residues. In this new set of experiments the CO<sub>2</sub> released after the first 12 hours at 25°C amounted to 12.1 ppm C with  $\delta^{13}\text{C}$  of +14.5‰ (compared to 12.8 ppm C and  $\delta^{13}\text{C}$  of +6.8‰ in the original experiment). For completeness note that the  $\delta^{18}\text{O}_{\text{SMOW}}$  value obtained herein was +18.7‰, assuming calcite, compared to +15.1‰ previously [1]. The CO<sub>2</sub> released during the next 12 hours, this time at 75°C, was equivalent to 170.6 ppm C with  $\delta^{13}\text{C}$  of +40.9‰ (21.3 ppm C and  $\delta^{13}\text{C}$  of -5.6‰ previously). After a further period at the same temperature the overall C yield for all steps was nearly 200 ppm with  $\delta^{13}\text{C}$  of +38.7‰ (compared to 43.7 ppm C and  $\delta^{13}\text{C}$  of -1‰ for the original experiment). So, in other words, it would seem that provided the sample under investigation is not removed from the acid during sequential etching, the overall yield of CO<sub>2</sub> is compatible with that expected, i.e. about 280 ppm C, on the basis of total carbon measurements [5]. The overall  $\delta^{13}\text{C}$  value is exactly what would be anticipated from the bulk of the carbonates in ALH 84001 [5].

So, there are two things to contemplate. Firstly, we can re-evaluate the results from the original study confident that they are real (although still difficult to understand). This necessarily means considering further the role of organic materials during the dissolution process. Secondly, we need to explain the difference in  $\delta^{13}\text{C}$  obtained from the first and subsequent extractions. In our experiments the first extractions were carried out at 25°C, with subsequent ones at 75°C. So, it is not merely time that is important here, but temperature as well. It is known that the composition of the carbonates plays a part here, with Ca-rich minerals reacting ahead of Mg-rich varieties. Future ion probe measurements should enable carbon isotopic data to be related directly to carbonate chemistry. In the meantime it is already known that there are wide variations in the carbon isotopic composition of the carbonates in ALH 84001 [1,6,7]. The results presented here would seem to confirm this.

The question to address is whether or not the variation in C isotopic composition of carbonates in ALH 84001 represents a primary effect which, in consequence, would have martian connotations. In this regard it should be stressed that meteorites collected from Antarctica are prone to becoming contaminated by terrestrial weathering products. From many other studies these are known to have  $\delta^{13}\text{C}$  around 0±10‰. Thus, it is entirely probable that the CO<sub>2</sub> released during the preliminary acid etch herein, or in the previous investigation [1], is predominantly from the reaction of Antarctic weathering products. If so, it is apparent that the bulk of the carbonates in ALH 84001 have  $\delta^{13}\text{C}$  values of about +40‰, which seems to be at odds with results from other studies [e.g. 6,7].

**References:** [1] Wright I. P. et al. (1997) *LPS*, XXVIII, 1589–1590. [2] McKay D. S. et al. (1996) *Science*, 273, 924–930. [3] McKay D. S. et al. (1997) *LPS XXVIII*, 919–920. [4] Gibson E. K. et al. (1998) *LPS XXIX*, abstract #1433. [5] Grady M. M. et al. (1994) *Meteoritics*, 29, 469. [6] Jull A. J. T. et al. (1995) *Meteoritics*, 30, 311–318. [7] Jull A. J. T. et al. (1997) *JGR (Planets)*, 102, 1663–1669.